Minority-carrier lifetime of $BaSi_2$ formed on various multicrystalline Si substrates

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Introduction We have been focusing on $BaSi_2$ as a new candidate material for thin-film solar cell because not only a large absorption coefficient (α=3×10^4 cm^{-1}@1.5 eV) but also a large minority-carrier lifetime (~10 μs) can be utilized in $BaSi_2$ epitaxial layers formed on a Si (111) substrate[1,2]. However, to realize the mass production of $BaSi_2$, inexpensive substrates such as multicrystalline Si (mc-Si) and glass are needed for $BaSi_2$ fabrication. Recently, we have formed $BaSi_2$ on mc-Si substrates. It is thus of significant importance to investigate the properties of non-epitaxial $BaSi_2$ films formed on those substrates. In this study, we fabricated $BaSi_2$ films on various mc-Si substrates with different grain size and grain orientations, and measured their minority-carrier properties by microwave-detected photoconductivity decay (μ-PCD) method.

Experiment We adopted two kinds of mc-Si substrates. The grains of substrate A are small and randomly oriented. On the other hand, substrate B has (111) highly oriented grains and larger grain size than substrate A. Over 500 nm undoped n-$BaSi_2$ layers capped with 8 nm α-Si were grown on those substrates by MBE method. The crystal orientation of $BaSi_2$ was investigated by X-ray diffraction (XRD). The minority-carrier lifetime was measured by μ-PCD method. Electron-hole pairs were generated by a 5 ns laser pulse with a wavelength of 349 nm and photoconductivity decay was measured by the reflectivity of microwave with the frequency of 26 GHz. The photon flux density was 1.1×10^{15}cm^{-2} s^{-1}.

Results & Discussions The effective lifetime (τ_{eff}) vs reflected microwave intensity (I) curves can be divided into three parts. According to our previous research, τ_{eff} of SRH recombination part can represent the lifetime of $BaSi_2$ layers [3]. Figure 1 shows the τ_{eff} of $BaSi_2$ grown on substrate A. We can see that sample1 grown at 580 ℃ had larger τ_{eff} than those of samples grown at holder temperatures of 550 & 600 ℃, meaning that 580 ℃ might be an appropriate temperature for $BaSi_2$ on substrate A. On the other hand, Fig. 2 shows the results of $BaSi_2$ grown on substrate B. In this case, sample 4 grown at 580 ℃ shows the roughest surface, which may attribute to the smallest τ_{eff} of 0.6 μs, possibly because that 580 ℃ was not sufficiently high for substrate B. Samples 5&6 were grown at 650 ℃ at the same time. Sample 6 had higher τ_{eff} than sample 5, which is probably due to the fact that the existence of epitaxial $BaSi_2$ part can attribute to higher τ_{eff} in sample 6. Comparing with τ_{eff} of epitaxial $BaSi_2$ grown on Si (111) substrates, those of $BaSi_2$ grown on mc-Si substrates show smaller τ_{eff} around 1 μs. This can be attributed to the crystal quality and surface roughness of $BaSi_2$ grown on mc-Si substrates.

References

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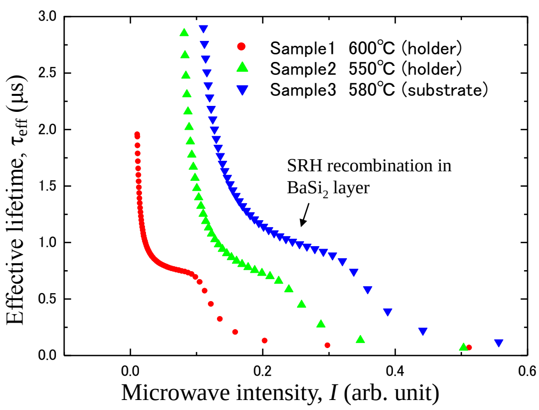

Fig 1 τ_{eff} as a function of the reflected microwave intensity (I) for samples 1-3 grown on substrate A. The photo density is 1.1×10^{15}cm^{-2}.

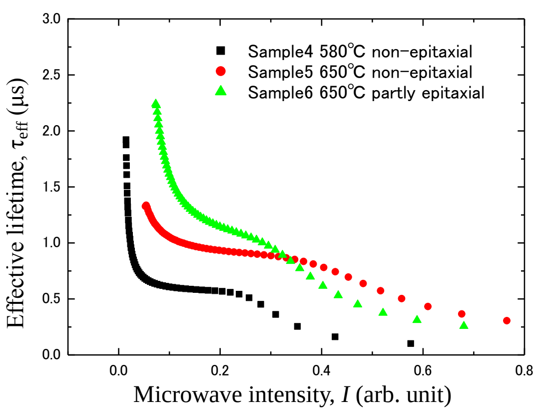

Fig 2 τ_{eff} as a function of the reflected microwave intensity (I) for samples 4-6 grown on substrate B. The photo density is 1.1×10^{15}cm^{-2}.